PATENT SPECIFICATION 748,427

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COMPLETE SPECIFICATION.

A Combination Process for Fractionating, Cracking and Coking Petroleum Hydrocarbons.

We, ESSO RESEARCH AND ENGINEERING COMPANY, (formerly known as STANDARD OIL DEVELOPMENT COMPANY), a Corporation duly organised and existing under the laws of the State of Delaware, United States of America, of Elizabeth, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

The present invention is concerned with improved methods and apparatus for the conversion of crude petroleum into more valuable products, and is particularly concerned with an improved and economical combination process and plant whereby high-octane gasoline and other valuable products may be obtained from crude petroleum, the process providing a high degree of control over the final products, whereby high-octane gasoline only may be produced if desired, and whereby the formation of residual fuel-oil is avoided as a final product.

In previously described methods it has been proposed to distil crude oils, thereby separating virgin naphthas, gas oils and reduced crudes, the gas oils being catalytically cracked to produce high-octane gasolines, and the reduced crudes further distilled under reduced pressure in vacuum stills to recover additional cracking feedstock therefrom.

Such processes require a multiplicity of fractionating towers and heating units together with extensive storage facilities for the various products and blends obtained. Heavy operating costs were incurred, the vacuum stills for example being particularly expensive to install, operate and maintain.

[*Price* 3*s* 0*d*.]

Various proposals have been made to provide integrated plants or "combination units" for the production of petroleum products. British Patent Specification No. 719,003 describes a combination unit comprising two fractionating columns namely a primary and a final-product column and one or more conversion units. After primary fractionation the fractions so obtained are introduced directly or after conversion at various levels in the final-product column, the residual fraction from the first column being stripped of remaining lighter hydrocarbons by countercurrent flow of hot hydrocarbon vapours comprising the light virgin naphthas and cracked and reformed gas-oil fractions. Final fractions, including residual fuel-oil fractions are taken from the final-product still.

An improved combination refining process has now been discovered which requires the use of a single fractionating column only, namely the final-product column, whereby full control is exercised over the final products. Using the improved process high-octane gasoline only may be produced if desired, although other fractions may also be produced. Residual fuel-oil fractions are eliminated altogether. Thus the valuable final-products, together with simplicity and economy of operation made the present invention a desirable advance over previous petroleum refining processes.

Broadly considered the present invention comprises the use of atmospheric and vacuum flash-drums in place of the primary fractionator heretofore used, and also includes coking and catalytic cracking units for conversion of heavy fractions to lighter fractions, the vapours being produced by the various processes being led to a final-product still. In carrying out the invention the

feedstock is preheated in a furnace at a pressure such that no vaporization takes place and thereafter enters the atmospheric flash drum, and the vapours separated therein are transferred to the final-product still, the liquid bottoms being reheated and passed to the vacuum flash-drum, where further vapours are separated under the reduced pressure therein and are passed to the final-products still, either directly or, through a catalytic cracking unit. Thus by using the arrangement of the two flash drums the separation of a substantial virgin vapourised fraction is achieved. The liquid bottoms from the vacuum flash-drum are converted into vaporised products by passage through a coking unit, the vapours thereby obtained being transferred to the final-products still. Solid petroleum coke is also produced during the coking stage, and is removed.

The desired petroleum fractions are withdrawn from the final product still. In the preferred form of the invention gasoline fractions alone may be withdrawn, although operating conditions may be so adjusted that gas oils and /or light and heavy naphthas may also be withdrawn from the fractionator. Usually a certain amount of gaseous hydrocarbons will also be produced and are also withdrawn. The residue remaining in the final-product still is withdrawn and passed through a catalytic cracking unit, wherein the said residue is transformed into high-octane gasoline fractions, the vapours thereof being passed to the final-product still.

In carrying out the present invention the feedstock may comprise whole petroleum crude or topped petroleum crude.

The invention therefore comprises a combination process for the conversion of a petroleum feedstock into lower boiling-point fractions comprising passing the said feedstock under pressure through one coil of a preheating furnace and thereafter into an atmospheric flash-drum wherein a portion of the heated feedstock is vapourised and passing the vapours obtained thereby to a fractionator, and recycling the liquid residue from the said atmospheric flash-drum through a separate coil section of the aforesaid preheating furnace and thereafter passing the heated liquid residue into a vacuum flash-drum wherein a portion of the said heated liquid residue is vapourised, and passing the vapours obtained thereby to the said fractionator, either directly or via a catalytic cracking unit wherein the said vapours are cracked to form fractions boiling within the gasoline range, passing the liquid residue from the vacuum flash-drum to a coking unit, wherein it is converted into solid petroleum coke and cracked hydrocarbon vapours and passing the said cracked hydrocarbon vapours to the said fractionator, and withdrawing gasoline from the said fractionator and recycling the residue from the said fractionator to the aforesaid catalytic cracking unit wherein the said residue is cracked to form fractions boiling within the gasoline range, the said fractions being passed to the said fractionator and withdrawn therefrom.

The invention also comprises the apparatus for carrying out the improved process hereinbefore described.

Referring to the drawing accompanying the Provisional Specification which is a diagrammatic representation of the apparatus which may be used to carry out the invention, the feedstock passes through a pump P and is conveyed along line A, entering the preheating furnace 1, being circulated therein through heating coils R. The heating furnace may conveniently be gas-fired, although any other suitable type of heating furnace may be employed. The feedstock is heated to a temperature between 700° and 900° F. The heated feedstock leaves the furnace in line B, being conveyed therein under pressure to the atmospheric flash-drum 2. The heated feedstock, on release to atmospheric pressure is separated into liquid and vapourised components. The vapours produced in the atmospheric flash-drum are passed along line C to fractionator 6, and the liquid residue in the atmospheric flash-drum is withdrawn and conveyed along line D and is recycled in the heating furnace, being circulated therein through heating coils R^1, and are thereafter conveyed under pressure in line E to the vacuum flash-drum 3. The pressure in the said vacuum flash-drum is maintained under an absolute pressure of 5 to 200 mm. Hg. preferably 20 to 100 mm. Hg. The heated liquid residue on being released to the reduced pressure is separated into vapourised, and heavy liquid components. The vapours produced in the vacuum flash-drum are passed along line F and may either join line C at junction Q, thereafter being conveyed to the fractionator 6, or they may be transferred along line F to a catalytic cracking unit 5, the vapours being therein cracked to form vapours of lower - boiling hydrocarbons, the cracked vapours being transferred along line L to junction Q thereafter passing along line C to the fractionator through port S.

The catalytic cracking unit should preferably be of the fluidized type, but without the fractionating column that is normally a part of such units. Generally considered such units comprise a cracking zone, wherein hydrocarbon vapour feed is contacted with a bed of catalyst particles maintained in a fluidized state, and a regeneration zone wherein a portion of the fluidized catalyst is continually undergoing regeneration, thereafter being returned to the cracking zone. Suitable catalyst particles comprise com-

posites of silica gel with alumina, magnesia and/or boria, activated alumina or activated clays. Suitable cracking temperatures are 800° to 1100° F. preferably 850° to 950° F. suitable regeneration temperatures are 1050° to 1150° F. The cracked vapours are continually withdrawn from the top of the reaction zone and separated from entrained catalyst particles.

The heavy liquid residue in the vacuum flash-drum is withdrawn and conveyed along line H to the coking unit 4. The coking unit may be any conventional type, such as those used for batch processes wherein the feedstock is heated to coking temperatures, usually within the range 900° to 1100° F., and discharged into a heat-insulated soaking drum to remain therein under coking conditions for a sufficient length of time to effect conversion into lower boiling-point products, the hard deposited coke being scraped out at intervals. Alternatively the so-called "delayed-coking" process may be used, or continuous processes may be employed, particularly those processes where inert coking particles such as sawdust, coke or sand are added to expedite the formation of petroleum coke. In all these coking processes the coking feed undergoes thermal cracking to produce low-boiling point hydrocarbons. Preferably however, a fluidized coking unit is employed, such as is described in British Patent Specification No. 724,117.

In all coking units the deposited solid petroleum coke is separated from the cracked vapours and is removed along line K, the said vapours being passed along line 1 to junction Q and thence along line C^1 to the final-product fractionating column 6. Although in the drawing all vapour streams are shown entering the fractionating column at the same point, it may be found desirable and convenient for the vapour streams to enter the fractionating columns at various levels, depending on their compositon and physical state. Thus the heavier vapour streams from the coking unit may enter at a lower level than the streams from the catalytic cracker or the atmospheric flash-drum. Thus generally the heavier vapour streams may be introduced into the fractionating columns at a lower level than the lighter vapour streams.

The fractionating column may be so operated that only gasoline fractions are withdrawn. If it is desired heavier fractions such as gas oils and/or kerosines may be also withdrawn. All the residues remaining after withdrawal, however, are withdrawn from the fractionator to pass to the catalytic cracking unit, as hereinbefore described.

What we claim is :—

1. A combination process for the conversion of a petroleum feedstock into lower boiling-point fractions comprising passing the said feedstock under pressure through one coil section of a preheating furnace and thereafter into an atmospheric flash-drum wherein a portion of the heated feedstock is vapourised and passing the vapours obtained thereby to a fractionator, and recycling the liquid residue from the said atmospheric flash-drum through a separate coil section in the aforesaid preheating furnace and thereafter passing the heated liquid residue into a vacuum flash-drum wherein a portion of the said heated liquid residue is vapourised, and passing the vapours obtained thereby to the said fractionator, either directly or via a catalytic cracking unit wherein the said vapours are cracked to form fractions boiling within the gasoline range, passing the liquid residue from the said vacuum flash-drum to a coking unit, wherein it is converted into solid petroleum coke and cracked hydrocarbon vapours and passing the said cracked hydrocarbon vapours to the said fractionator, and withdrawing gasoline from the said fractionator and recycling the residue from the said fractionator to the aforesaid catalytic cracking unit wherein the said residue is cracked to form fractions boiling within the gasoline range, the said fractions being passed to the said fractionator and withdrawn therefrom.

2. A process as claimed in Claim 1 wherein the feedstock is heated to a temperature between 700° and 900° F. in the furnace.

3. A process as claimed in Claim 1 or 2 wherein the said vacuum flash-drum is maintained at a pressure of from 5 to 200 mm. Hg, preferably from 20 to 100 mm. Hg.

4. A process as claimed in any of Claims 1 to 3 wherein the said cracking unit is a fluidized cracking unit, substantially as hereinbefore described.

5. A process as claimed in any of Claims 1 to 4 wherein the said coking unit is a fluidized coking unit substantially as hereinbefore described.

6. A process as claimed in any of Claims 1 to 6 wherein gas oils and/or light and heavy naphthas are withdrawn from the said fractionating column.

7. Apparatus for carrying out the processes as claimed in any of Claims 1 to 6, substantially as hereinbefore described.

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PROVISIONAL SPECIFICATION.

A Combination Process for Fractionating, Cracking and Coking Petroleum Hydrocarbons.

We, STANDARD OIL DEVELOPMENT COMPANY, a Corporation duly organised and existing under the laws of the State of Delaware, United States of America, of Elizabeth, New Jersey, United States of America, do hereby declare this invention to be described in the following statement :—

The present invention is concerned with improved methods and apparatus for the conversion of crude petroleum into more valuable product, and is particularly concerned with an improved and economical combination process and plant whereby high-octane gasoline and other valuable products may be obtained from crude petroleum, the process providing a high degree of control over the final products, whereby high-octane gasoline only may be produced if desired, and whereby the formation of residual fuel-oil is avoided as a final product.

In previously described methods it has been proposed to distil crude oils, thereby separating virgin naphthas, gas oils and reduced crudes, the gas oils being catalytically cracked to produce high-octane gasolines, and the reduced crudes further distilled under reduced pressure in vacuum stills to recover additional cracking feedstock therefrom.

Such processes require a multiplicity of fractionating towers and heating units together with extensive storage facilites for the various products and blends obtained. Heavy operating costs were incurred, the vacuum stills for example being particularly expensive to install, operate and maintain.

Various proposals have been made to provide integrated plants or " combination units " for the production of petroleum products. Copending Application No. 23880/52 describes and claims a combination unit comprising two fractionating columns only, namely a primary and a final-product column. After primary fractionation the products after further treatment are introduced at various levels in the final-product column, the crude-bottoms being stripped of remaining lighter hydrocarbons by countercurrent flow of hot hydrocarbon vapours comprising the light virgin naphthas and cracked and reformed gas-oil fractions. Final fractions, including residual fuel-oil fractions are taken from the final-product still.

An improved combination refining process has now been discovered which requires the use of a single fractionating column only, namely the final-product column, whereby full control is exercised over the final products. Using the improved process high-octane gasoline only may be produced if desired, although other fractions may also be produced. Residual fuel-oil fractions are eliminated altogether. Thus the valuable final-products, together with simplicity and economy of operation made the present invention a desirable advance over previous petroleum refining processes.

Broadly considered the present invention comprises the use of atmospheric and vacuum flash-drums in place of the primary fractionator heretofore used, and also includes coking and catalytic cracking units for conversion of heavy fractions to lighter fractions, the vapours being produced by the various processes being led to a final-product still. In carrying out the invention preheated feedstock enters the atmospheric flash drum, and the vapours separated therein are transferred to the final-product still, the liquid bottoms being reheated and passed to the vacuum flash-drum, where further vapours are separated under the reduced pressure therein and are passed to the final-products still, either directly or through a catalytic cracking unit. Thus by using the arrangement of the two flash drums the separation of a substantial virgin vapourised fraction is achieved. The liquid bottoms from the vacuum flash-drum are converted into vapourised products by passage through a coking unit, the vapours thereby obtained being transferred to the final-products still. Solid petroleum coke is also produced during the coking stage, and is removed.

The desired petroleum fractions are withdrawn from the final product still. Gasoline fractions alone may be withdrawn if desired, although gas oils and/or light and heavy naphthas may also be withdrawn. Usually a certain amount of gaseous hydrocarbons will also be produced and are also withdrawn. The residue remaining in the final-product still is withdrawn and passed through a catalytic cracking unit, wherein the said residue is transformed into high-octane gasoline fractions, the vapours thereof being passed to the final-product still. Thus by adjusting the operating conditions a 100% yield of high-octane gasoline may be obtained.

In carrying out the present invention the feedstock may comprise whole petroleum crude or topped petroleum crude.

The invention therefore comprises a com-

bination process for the conversion of a petroleum feedstock into lower boiling-point fractions comprising passing the said feedstocks through a preheating furnace and thereafter into an atmospheric flash-drum wherein a portion of the heated feedstock is vapourised and passing the vapours obtained thereby to a fractionator, and recycling the liquid residue from the said atmospheric flash-drum through the aforesaid preheating furnace and thereafter passing the heated liquid residue into a vacuum flash-drum wherein a portion of the said heated liquid residue is vapourised, and passing the vapours obtained thereby to the said fractionator, either directly or via a catalytic cracking unit wherein the said vapours are cracked to form fractions boiling within the gasoline range, passing the liquid residue from the said vacuum flash-drum to a coking unit, wherein solid petroleum coke and cracked hydrocarbon vapours are produced and passing the said cracked hydrocarbon vapours to the said fractionator, and withdrawing from the said fractionator such petroleum fractions as are desired and recycling the residue from the said fractionator to the aforesaid catalytic cracking unit wherein the said residue is cracked to form fractions boiling within the gasoline range, the said fractions being passed to the said fractionator.

The invention also comprises the apparatus for carrying out the improved process hereinbefore described.

Referring to the accompanying drawing which is a diagrammatic representation of the apparatus which may be used to carry out the invention, the feedstock passes through a pump P and is conveyed along line A, entering the preheating furnace 1, being circulated therein through heating coils R. The heating furnace may conveniently be gas-fired, although any other suitable type of heating furnace may be employed. The feedstock is heated to a temperature between 700° and 900° F. The heated feedstock leaves the furnace in line B, being conveyed therein under pressure to the atmospheric flash-drum 2. The heated feedstock, on release to atmospheric pressure is separated into liquid and vapourised components. The vapours produced in the atmospheric flash-drum are passed along line C to fractionator 6, and the liquid residue in the atmospheric flash-drum is withdrawn and conveyed along line D and are recycled in the heating furnace, being circulated therein through heating coils R^1, and are thereafter conveyed under pressure in line E to the vacuum flash-drum 3. The pressure in the said vacuum flash-drum is maintained under a reduced pressure of 5 to 200 mm. Hg, preferably 20 to 100 mm. Hg. The heated liquid residue on being released to the reduced pressure is separated into vapourised, and heavy liquid components. The vapours produced in the vacuum flash-drum are passed along line F and may either join line C at junction Q, thereafter being conveyed to the fractionator 6, or they may be transferred along line F to a catalytic cracking unit 5, the vapours being therein cracked to form vapours of lower-boiling hydrocarbons, the said vapours being transferred along line L to junction Q thereafter passing along line C to the fractionator through port S.

The catalytic cracking unit should preferably be of the fluidized type, but without the fractionating column that is normally a part of such units. Generally considered such units comprise a cracking zone, wherein hydrocarbon vapour feed is contacted with a bed of catalyst particles, maintained in a fluidized state and a regeneration zone wherein a portion of the fluidized catalyst is continually undergoing regeneration, thereafter being returned to the cracking zone. Suitable catalyst particles comprise composites of silica gel with alumina, magnesia and/or boria, activated alumina or activated clays. Suitable cracking temperatures are 800° to 1100° F. preferably 850° to 950° F. suitable regeneration temperatures are 1050° to 1150° F. The cracked vapours are continually withdrawn from the top of the reaction zone and separated from entrained catalyst particles.

The heavy liquid residue in the vacuum flash-drum is withdrawn and conveyed along line H to the coking unit 4. The coking unit may be any conventional type, such as those used for batch processes wherein the feedstock is heated to coking temperatures, usually within the range 900° to 1100° F., and discharged into a heat-insulated soaking drum to remain therein under coking conditions for a sufficient length of time to effect conversion into lower boiling-point products, the hard deposited coke being scraped out at intervals. Alternatively semi-continuous processes, or continuous processes may be employed, particularly those processes where said coking particles such as sawdust, coke or sand are added to expedite the formation of petroleum coke. In all these coking processes the coking feed undergoes thermal cracking to produce low-boiling point hydrocarbons. Preferably however, a fluidized coking unit is employed, such as is described and claimed in copending Applications No. 28516/51 or No. 10018/52.

In all coking units the deposited solid petroleum coke is separated from the cracked vapours and is removed along line K, the said vapours being passed along line I to junction Q and thence along line C^1 to the final product fractionating column 6. Although in the accompanying drawing all

vapour streams are shown entering the fractionating column at the same point, it may be found desirable and convenient for the vapour streams to enter the fractionating columns at various levels, depending on their composition and physical state. Thus the heavier vapour streams from the coking unit may enter at a lower level than the streams from the catalytic cracker or the atmospheric flash-drum. Thus generally the heavier vapour streams may be introduced into the fractionating columns at a lower level than the light vapour streams.

The fractionating column may be so operated that only gasoline fractions are withdrawn. If it is desired heavier fractions such as gas oils and/or kerosines may be also withdrawn. All the residues remaining after withdrawal, however, are withdrawn from the fractionator to pass to the catalytic cracking unit, as hereinbefore described.

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748,427 PROVISIONAL SPECIFICATION
1 SHEET

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